

Jet Physics at CDF

KENICHI HATAKEYAMA[†]
FOR THE CDF COLLABORATION

The Rockefeller University, 1230 York Avenue, New York, NY, U.S.A.

Recent results on jet physics at the Fermilab Tevatron $p\bar{p}$ collider from the CDF Collaboration are presented. The main focus is put on results for the inclusive jet and dijet, $b\bar{b}$ dijet, W/Z +jets and $W/Z+b$ -jets production.

1. Inclusive and dijet production

The differential inclusive jet cross section and dijet cross section at the Tevatron test QCD at the shortest distances currently attainable in accelerator experiments. The measurements provide a fundamental test of QCD and a constraint on the parton distribution functions (PDFs) of the proton. The dijet mass spectrum is also sensitive to the presence of new particles that decay into two jets.

CDF has made inclusive jet cross section measurements using the k_T algorithm and Midpoint cone clustering algorithm. The recent measurements using these algorithms are based on the 1.0 and 1.13 fb⁻¹ of data, respectively, and cover the rapidity region up to $|y_{jet}| = 2.1$ which is much wider than $0.1 < |y_{jet}| < 0.7$ in the previous measurements. The k_T measurement was published in [1] and the results from the Midpoint measurement are shown in Fig. 1. The measured cross sections are in agreement with next-to-leading order (NLO) perturbative QCD (pQCD) predictions based on CTEQ6.1M PDF. The measurements in the forward region show that the experimental uncertainties are somewhat smaller than the PDF uncertainties, and this measurement is expected to further constrain the PDFs.

The dijet mass differential cross section was measured using the 1.13 fb⁻¹ of data with the Midpoint algorithm. The measured dijet mass spectrum was found to be in good agreement with NLO pQCD predictions within the uncertainties. Limits on the cross sections for new particles decaying into two jets have been worked out using this measurement.

[†] hatakek@mail.rockefeller.edu

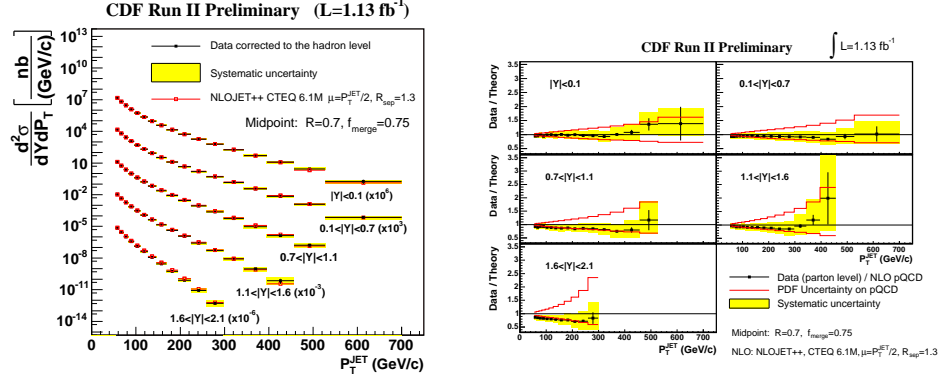


Fig. 1. (*left*) measured inclusive jet differential cross sections in five rapidity regions compared to NLO pQCD predictions; (*right*) ratios of the measured cross sections over the NLO pQCD predictions.

2. $b\bar{b}$ dijet production

The $b\bar{b}$ dijet production cross section has been measured using 260 pb⁻¹ of data collected by triggering on two displaced tracks and two jets. $b\bar{b}$ dijet events are selected by requiring two jets with $|\eta_{1,2}| < 1.2$ and $E_{T,1} > 35$ GeV and $E_{T,2} > 32$ GeV, respectively, which are tagged as b -jets by a secondary vertex algorithm. The measured $b\bar{b}$ differential cross section is compared to Pythia Tune A [2], Herwig with Jimmy [3], and MC@NLO [4] with and without Jimmy as a function of $\Delta\phi$. Tune A refers to a special set of Pythia parameters tuned to give a reasonable description of the underlying event (UE), and Jimmy is a program which can be used in Herwig and MC@NLO to add multiple parton interactions to events to improve the description of UE. MC@NLO+Jimmy provides the best description of the data indicating the importance of both the next-to-leading order contribution and UE effect.

3. W/Z +jets and $W/Z + b$ -jets production

The W/Z +jets and $W/Z + b$ -jets production has been studied intensively at CDF. The studies of these processes provide important tests of pQCD predictions at high momentum transfers. Final states containing W/Z and (b -)jets are signal channels for many interesting processes such as $t\bar{t}$ or single top production, as well as searches for the Higgs boson in the $W/Z + H \rightarrow W/Z + b\bar{b}$ channel and physics beyond the Standard Model (SM) such as Supersymmetry. The production of W/Z +jets via QCD constitutes a large background to these processes, and thus it is essential to understand these

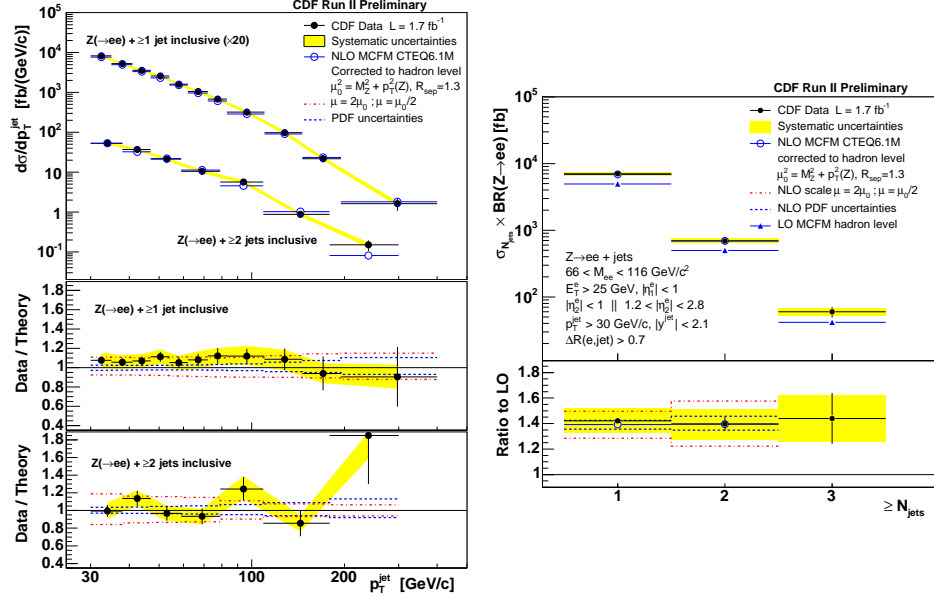


Fig. 2. (left) Measured inclusive cross section for Z +jets production as a function of p_T^{jet} compared to NLO pQCD predictions. (right) Measured cross section as a function of inclusive jet multiplicity compared to NLO pQCD predictions.

processes accurately.

The W +jets cross sections were measured using $W \rightarrow e\nu$ events from the 320 pb^{-1} of data for four inclusive jet multiplicities ($N_{jets} \geq 1, 2, 3, 4$), and compared to NLO pQCD predictions from MCFM [5] and LO matrix element (ME) + parton shower (PS) Monte Carlo predictions based on the CKKW [6] and MLM (as in Alpgen [7]) matching schemes. The LO ME+PS predictions are systematically lower than the measured cross sections; however, all the predictions are in agreement with data in the cross section ratios σ_n/σ_{n-1} , where $\sigma_n = \sigma(W \rightarrow e\nu + \geq n\text{-jet}; E_{T, n\text{-th jet}} \geq 25 \text{ GeV})$.

The Z +jets cross sections were measured using $Z \rightarrow e^+e^-$ events from the 1.7 fb^{-1} of data for jets in the kinematic region of $p_T^{jet} > 30 \text{ GeV}/c$ and $|y_{jet}| < 2.1$. Fig. 2 shows the measured differential inclusive jet cross sections as a function of p_T^{jet} in Z +jets production for $N_{jet} \geq 1$ and $N_{jet} \geq 2$ and the total cross sections, $\sigma_{N_{jet}}$, for Z +jets events up to the $N_{jet} \geq 3$ bin. Good agreement was observed between data and NLO pQCD predictions from MCFM [5] up to the $N_{jet} \geq 2$ bin where NLO predictions are available. The ratio of the data to the LO pQCD calculations indicates that the LO pQCD predictions underestimate the data by a factor of about 1.4 and this

Table 1. Results on the $Z + b$ -jet production.

	CDF Data	Pythia	NLO	NLO+UE +Hadronization
$\sigma(Z + b\text{-jet})$	$0.94 \pm 0.15 \pm 0.15$ pb	n.a.	0.51 pb	0.56 pb
$\sigma(Z + b\text{-jet})/\sigma(Z)$	$0.369 \pm 0.057 \pm 0.055$ %	0.35 %	0.21 %	0.23 %
$\sigma(Z + b\text{-jet})/\sigma(Z + \text{jet})$	$2.35 \pm 0.36 \pm 0.45$ %	2.18 %	1.88 %	1.77 %

factor is constant over inclusive jet multiplicities up to the $N_{jet} \geq 3$ bin.

CDF has recently updated the measurement on $Z + b$ -jet production using 1.5 fb^{-1} of data. The measurement was made using jets with $E_T > 20 \text{ GeV}$ and $|\eta| < 1.5$ tagged as b -jets by the secondary vertex algorithm in $Z \rightarrow e^+e^-$ and $Z \rightarrow \mu^+\mu^-$ events and the results are summarized in Table. 1. The measured $Z + b$ -jet cross section and its fractions in the Z events and Z +jets events are found to be somewhat higher than the NLO pQCD predictions, and the $Z + b$ -jet fractions are in better agreement with predictions from Pythia Tune A. The differences between the NLO predictions and Pythia are being investigated.

4. Summary

CDF has a broad program on jet physics including the measurements on inclusive jet, dijet, $b\bar{b}$ dijet and boson+ (b) -jets production, and is making a significant impact on better understanding of jet production and QCD. These measurements provide tests of pQCD calculations and Monte Carlo event generators, and constraints on the proton PDFs. QCD processes are often important backgrounds to electroweak and possible new physics processes, and thus better understanding of QCD processes will enhance the potential for new physics discoveries at the Tevatron and also at the upcoming LHC.

REFERENCES

- [1] A. Abulencia *et al.*, Phys. Rev. D **75**, 092006 (2007).
- [2] R. Field, presented at Fermilab ME/MC Tuning Workshop, October 4, 2002.
- [3] J. M. Butterworth *et al.*, Z. Phys. C **72**, 637 (1996).
- [4] S. Frixione and B. R. Webber, JHEP **0206**, 029 (2002).
- [5] J.M. Cambell *et al.*, Phys. Rev. D **69**, 074021 (2004).
- [6] S. Catani *et al.*, J. High Energy Phys. **0111**, 063 (2001); F. Krauss, J. High Energy Phys. **0208**, 015 (2002).
- [7] M. L. Mangano *et al.*, JHEP **0307**, 001 (2003).